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APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E, R-1 #35

COST *(In Millions)*	FY 2000	FY2001	FY2002	FY2003	FY2004	FY2005	FY2006	FY2007	Cost To Complete	Total Cost
Total Program Element (PE) Cost	19.187	37.474	153.700	64.000	86.000	89.000	94.000	94.000	Continuing	Continuing
Advanced Aerospace Systems ASP-01	19.187	37.474	153.700	64.000	86.000	89.000	94.000	94.000	Continuing	Continuing

(U) <u>Mission Description:</u>

(U) The Advanced Aerospace Systems program element is budgeted in the Advanced Technology Development budget activity because it addresses high payoff opportunities to dramatically reduce costs associated with advanced aeronautical and space systems or provide revolutionary new system capabilities for satisfying current and projected military mission requirements. Research and development of integrated system concepts, as well as enabling vehicle subsystems will be conducted.

(U) The Supersonic Miniature Air-Launched Interceptor (MALI) program will demonstrate an inexpensive supersonic air platform with a low cost infrared (IR) sensor to provide cruise missile defense by exploiting large rear aspect IR signatures and overtaking incoming missiles from the rear. As a further cost reduction, the program will leverage off the existing miniature air-launched decoy (MALD) program's technology and off board surveillance and tracking sensors to provide tail-on missile end game opportunities. An advanced unmanned air vehicle avionics development and emerging payload effort will be incorporated into the MALI core program due to the required data transmit/receive survivability configuration of the interceptor mission.

(U) The Navy and the Marine Corps have a need for affordable, survivable, vertical take-off and landing (VTOL) unmanned air vehicles (UAV) to support dispersed units in littoral and urban areas. DARPA, in partnership with the Office of Naval Research (ONR) and industry, has formulated the Advanced Air Vehicle (AAV) program to explore two innovative vertical take-off and landing (VTOL) concepts with the potential for significant performance improvements that would satisfy stressing mission needs. The first, an advanced Canard Rotor/Wing (CRW) aircraft, offers the potential for a high speed, rapid response capability from a VTOL unmanned air vehicle with significant range and stealth improvements as compared to other VTOL concepts. Design and fabrication of this scaled vehicle concept will validate the command and control, stability and control system and aerodynamic performance required for vertical take-off, landing and hover via a rotating center wing that stops and locks in place for efficient high speed cruise. The second concept (A160), will exploit a hingeless, rigid, rotor concept to produce a VTOL unmanned air vehicle

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with very low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. This unique concept offers the potential for significant increases in VTOL UAV range (>2000nm) and endurance (>24-48 hours). Detailed design, fabrication and testing of this concept will be conducted to establish its reliability, maintainability and performance. Both the CRW and A160 are being explored for surveillance and targeting, communications and data relay, lethal and non-lethal weapons delivery, assured crew recovery and special operations missions in support of Navy, Marine Corps, Army and other Agency needs.

(U) The Orbital Express Space Operations Architecture program will develop and demonstrate autonomous techniques for on-orbit refueling and reconfiguration of satellites that could support a broad range of future U.S. national security and commercial space programs. An important element of the program is the enabling nature of such capability for new space missions and its potential to reduce space program costs through spacecraft life extension ("Pre Planned Product Improvement," or "P3I"), comparable to what is done today with aircraft. During Phase I (Concept Definition) the type of satellite servicing to be emulated in the on-orbit demonstration will be identified (to include the type of hardware upgrades and reconfiguration to be supported, and the techniques to be adopted in transferring hardware and fuel between spacecraft), and detailed designs will be developed for "industry standard," nonproprietary satellite-to-satellite mechanical and electrical interfaces enabling on-orbit hardware and fluid transfers. A preliminary system design will emerge in conjunction with developments in software and sensors necessary for autonomous space operations to assess the potential significant cost savings for space operations. In Phase II, detailed design of the on-orbit demonstration spacecraft (the service vehicle, the demonstration "target," or serviced satellite, and the depot for replacement hardware and fuel) will occur and the spacecraft will be fabricated, integrated, ground tested, and space-qualified. In FY 2004, the demonstration spacecraft will be launched. On-orbit, the Orbital Express spacecraft will repeatedly demonstrate the feasibility of autonomously upgrading, refueling and reconfiguring satellites. Following an initial 4-6 month demonstration, the Orbital Express demonstration system will be transitioned to a follow-on customer for additional test and evaluation. (The FY 2001 funding of this program's technology development is exploiting the development of advanced tactical technology concepts and compact laser technologies (approximately $5 million) funded under PE 0602702E, Project TT-06 in FY 2000 as well as other efforts in this Project, ASP-01.)

(U) Within the joint DARPA/Air Force UCAV program, this project will continue risk reduction and "Concept of Operation" evaluation for the Unmanned Combat Air Vehicle. This project will complete the design of the system B demonstrator (X-45B Low Observability (LO) air vehicle, mission control system (MCS), and support segment) and begin development of its tailored sensor and communications suite. Ultimately, this program will support the goal to demonstrate the technical feasibility, military utility and operational value of a UCAV system to effectively and affordably perform SEAD/Strike missions in the 2010 timeframe. The FY 2002 program reflects continuation of an expanded and accelerated UCAV program that was initiated by the Congress through a major funding increase in FY 2001 (budgeted in PE 0602702E, project TT-12).

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(U) The goal of the Naval Unmanned Combat Air Vehicle (UCAV-N) advanced technology demonstration program is to validate the technical feasibility for a naval unmanned combat air system to effectively and affordably perform naval Suppression of Enemy Air Defense (SEAD)/Strike/Surveillance missions within the emerging global command and control architecture. This advanced technology demonstration initiative will investigate and validate the critical technologies, processes and system attributes associated with the development of a UCAV-N system. The proposed UCAV-N design will be suitable for aircraft carrier use but will also stress maximum commonality with the Air Force UCAV.

(U) Analysis of the legacy force carrier air wing together with an additional 12 to 16 multi-mission Strike, SEAD and Surveillance unmanned combat aircraft that are suitable for aircraft carrier use and capable of penetrating fully operational enemy air defense systems are areas of investigation. It is also important to develop and demonstrate a low life cycle cost (LCC) combat effective design for a multi-mission Strike, SEAD and Surveillance unmanned air vehicle while demonstrating robust and secure command, control and communications peculiar to the maritime environment, including line-of-sight, non-line-of-sight, and over-the-horizon.

(U) Hybrid Cycle and Rocket program will develop and demonstrate the suitability of hybrid cycle propulsion, like airbreathing and rocket hybrid engines, and liquid and solid hybrid rocket motors, for high-performance tactical missiles and cost effective space access. Recent advances have made this technology viable for wider use in missiles and space booster applications. This program seeks to demonstrate hybrid technologies at the scales appropriate for tactical missiles, sounding rockets and stages for small launch vehicles. For space launch applications, this program also seeks to demonstrate hybrid technologies that have levels of reusability. During Phase I (Concept Definition) mission utility studies will be performed to focus the planned demonstrations towards viable applications. In this early phase, hybrid technologies will be demonstrated at the scale required for the final demonstrations. Critical reusability technologies will be demonstrated. During Phase II (Detailed Design and Subsystem Demonstration) detailed design of the entire booster and demonstration vehicle will be completed and ground tested. Phase III (Flight Demonstrations) will fly small-scale rocket boosters with reusable hybrid engines.

(U) The Quiet Supersonic Platform (QSP) program is directed towards development and validation of critical technology for long-range advanced supersonic aircraft with substantially reduced sonic boom, reduced takeoff and landing noise, and increased efficiency relative to current-technology supersonic aircraft. Improved capabilities include supersonic flight over land without adverse sonic boom consequences with boom overpressure rise less than 0.3 pounds per square foot, increased unrefueled range approaching 6,000 nmi, gross take-off weight approaching 100,000 pounds, increased area coverage and lower overall operational cost. Highly integrated vehicle concepts will be explored to simultaneously meet the cruise range and noise level goals. Advanced airframe technologies will be explored to minimize sonic boom and vehicle drag including

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natural laminar flow, aircraft shaping, plasma, heat and particle injection, and low weight structures. In FY 2000, this program was funded in PE 0602702E, Project TT-07.

(U) Both the U.S. military and the U.S. economy increasingly depend on space platforms for command, control, communications, intelligence, surveillance, reconnaissance, meteorology, navigation and other functions. With this increasing dependence comes increased vulnerability to attack on space platforms and their ground based infrastructures. This project is developing technologies that enable survivable and robust space systems. The project consists of: Space Protection and Warning (SPAWN); Space Battle Management Command, Control and Communications ($SBMC^3$); and Space Object Identification System (SOIS). The SPAWN, $SBMC^3$, and SOIS programs are closely coordinated with the US Air Force and USCINCSPACE, and with DARPA's Advanced Space Surveillance Telescope (project SGT-02), Orbital Express (project ASP-01), and classified programs.

(U) The Satellite Protection and Warning (SPAWN) program will examine the impact of emerging micro and nano satellite threats (both offensive and defensive) to critical U.S. space assets, develop technologies, and devise techniques to counter these threats taking advantage of a satellite-servicing infrastructure. Potential solutions include delivery of expendable modules for satellite self-defense, ride along sensor packages and micro satellites that use a servicing spacecraft as a mother ship. A secondary goal is to explore novel methods and sensors to distinguish natural space phenomena from manmade attack. In Phase I the satellite warning and protection functions that will be emulated in the on-orbit demonstration will be examined, including detection, inspection and characterization of potentially hostile payloads, assessment of friendly payloads, and detection of electromagnetic surveillance. A preliminary system design will detail the number, types and configurations of sensors as well as the software required for target detection and assessment from which a warning condition will initiate an autonomous protection sequence. In Phase II, detailed design of the on-orbit demonstration spacecraft will occur and the spacecraft will be fabricated, ground tested, and space-qualified. Finally, in FY 2005, the SPAWN demonstration spacecraft will be launched. During the first 4-6 months on-orbit, the Orbital Express experiment will repeatedly demonstrate the feasibility of autonomously upgrading, refueling and reconfiguring satellites. SPAWN will view these dockings on a non-interfering basis. Following the demonstration period, SPAWN will conduct proximity operations including detection, tracking, target inspection, and electromagnetic surveillance detection.

(U) The Space Battle Management Command, Control and Communications ($SBMC^3$) program will develop computing and communications technologies that will enable space forces to dominate the battlespace through automated spacecraft tracking and control, fusion of space surveillance sensor information, and assured command and control of space control assets. $SBMC^3$ will provide algorithms that enable fusion and handoff of data between space sensors of widely different sensing modalities, locations, and reporting intervals. Protocols for information exchange

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within the space control architecture will be optimized. Information systems for highly automated space object tracking, identification, and activity assessment and spacecraft control will be developed. The space control battle management architecture will feature streamlined human interaction for more rapid action timelines and reduced error rates, in an environment of ever increasing numbers of vehicles being controlled and objects being tracked, while maintaining assured human control of space activities.

(U) The Space Object Identification System (SOIS) program will develop sensing options for the imaging and characterization of objects in earth orbit. A special emphasis will be placed on imaging small, faint objects at orbits ranging from low-earth orbit to geo-stationary orbit. Technologies under consideration will include ground-based ladar and coherent radar, as well as space-based optical, infrared, and ladar sensors. The program will investigate novel focal plane array materials for the passive imaging of cold, faint objects and novel signal processing algorithms for non-imaging characterization. The capabilities emerging from this program will enable the classification of unknown objects, such as space debris, as well as the monitoring of the health and status of operational satellites.

(U) The Space Technologies Program will develop and demonstrate advances in smart materials, multifunctional materials and power electronics to provide gains in the performance of space structures and systems. This work will include materials, devices and novel structural systems that will allow for large scale changes in shape and function with minimal energy/power requirements for shape control, and, adaptation on-orbit to precisely align highly packaged spacecraft. This task will also demonstrate an electronics module that utilizes the hybridization of cryogenic, superconducting and conventional room temperature power electronics for optimum performance of satellite systems. This hybridization translates to modules with increases of efficiency of factors of two to four, at least 10 times lower system noise and significant reductions in size and weight that scale with the overall size of the system.

(U) <u>Program Accomplishments and Plans:</u>

(U) <u>FY 2000 Accomplishments:</u>

- Advanced Air Vehicle (AAV). ($ 10.175 Million) [Future Combat Systems – related = $5.000 Million]
  - Completed preliminary and detailed design; began fabrication of two CRW demonstrators.

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- Conducted tests of A160 air vehicle flight control system and rotor assembly.
- Continued fabrication of two A160 prototypes.

• Supersonic Miniature Air-Launched Interceptor (MALI). ($ 3.991 Million)
- Conducted Critical Design Review to establish vehicle configuration.
- Initiated engine and infrared (IR) payload testing.
- Initiated fabrication, assembly and risk reduction testing of air vehicle.
- Developed airborne inter-vehicle communications, mission processing and execution capability.
- Initiated test planning for flight demonstration of interceptor and collaborative formation mission.
- Explored other concepts for low cost MALI airframes to fill mission areas such as reconnaissance, surveillance, nuclear/biological/chemical (NBC) detection and jamming.

• Orbital Express Space Operations Architecture. ($ 5.021 Million)
- Initiated Phase I to identify, define and analyze the requirements for on-orbit satellite servicing.
- Began to analyze the utility, cost effectiveness and life-cycle costs.
- Started the Operational System Concept (OSC) redefinition.
- Began nomination process of a baseline satellite-servicing mission.
- Initiated the concept of operations (CONOPS) for servicing.

(U) <u>FY 2001 Plans:</u>

• Advanced Air Vehicle: Hummingbird Warrior. ($ 2.979 Million)
- Initiate flight tests of A160 air vehicle.
- Design sensor integration modifications to A160 air vehicle.
- Design low-vibration rotor modifications for A160.

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- Design unmanned ground vehicle (UGV) deployment system for A160.
- Study A160 scaling and signature reduction.

• Supersonic Miniature Air-Launched Interceptor (MALI). ($ 7.810 Million)
- Complete air vehicle fabrication, assembly and conduct ground testing.
- Complete engine and infrared (IR) payload testing.
- Demonstrate inter-vehicle communications, mission processing and execution capability.
- Perform supersonic engine flight verification and seeker/advanced payload verification.
- Conduct flight demonstration of subsonic vehicle interceptor and collaborative formation flying mission.
- Conduct free flight intercept demonstration against a representative target.
- Continue to explore alternative mission concepts for low cost MALI airframes, including ground-launched variant of interceptor vehicle for use by land forces.

• Orbital Express Space Operations Architecture. ($ 6.825 Million)
- Continue the identification, definition and analysis of the requirements for on-orbit satellite servicing.
- Continue to analyze the utility, cost effectiveness and life-cycle costs.
- Continue redefinition of the Operational System Concept (OSC).
- Continue nomination process of a baseline satellite-servicing mission.
- Continue to define a servicing concept of operations (CONOPS).
- Define a draft, non-proprietary satellite-to-satellite interface standard.
- Perform risk reduction research and development activities of critical items.
- Complete initial demonstration test plan.
- Conduct preliminary design review and develop Request for Proposals in preparation for Phase II.

• Quiet Supersonic Platform. ($ 19.860 Million)
- Continue development of technologies for long-range supersonic aircraft having low sonic boom and noise signature, range augmentation through low vehicle drag and system weight reduction.

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- Develop conceptual designs for highly integrated supersonic long-range aircraft.

(U) **<u>FY 2002 Plans:</u>**

- Advanced Air Vehicle: Hummingbird Warrior. ($ 9.000 Million)
  - Fabricate and test low vibration rotor modifications for A160 air vehicle.
  - Integrate/demonstrate electro-optic/infrared (EO/IR) surveillance payload on A160 vehicle.
  - Integrate/demonstrate unmanned ground vehicle (UGV) deployment system on A160 vehicle.

- Supersonic Miniature Air-Launched Interceptor (MALI). ($ 3.000 Million)
  - Complete supersonic vehicle testing, final report and transition

- Orbital Express Space Operations Architecture. ($ 35.700 Million)
  - Complete Phase I.
  - Conduct Source Selection and initiate Phase II of the demonstration system.
  - Complete demonstration system detailed design including standard (non-proprietary) satellite-to-satellite electrical and mechanical interfaces.
  - Develop key enabling technologies and continue risk reduction activities.
  - Initiate fabrication of demonstration system/subsystems.
  - Initiate Auto Guidance, Navigation and Control (GN&C) system and software design.

- Unmanned Combat Air Vehicle (UCAV). ($ 60.000 Million)
  - Complete design and development of a third air vehicle (X-45B), which incorporates integrated apertures and antennas, integrated weapons, distributed avionic, Low-Observability (LO) treatments and exhaust, and increased functionality.
  - Conduct high-fidelity component radar cross-section (RCS) testing.
  - Initiate development of an advanced electronic support measures (ESM) subsystem, synthetic aperature radar (SAR), and satellite communication terminal tailored for the X-45B.

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- Complete design of a fully C2 interoperable mission control system (MCS) incorporating multilevel security features in both hardware and software.
- Complete design and begin development of the X-45B container and support equipment.

• Naval Unmanned Combat Air Vehicle (UCAV-N). ($ 27.000 Million)
  - Conduct demonstrations of technologies, processes, and systems attributes to demonstrate the feasibility of Naval UCAVs to operate from ships and conduct maritime network centric warfare
  - Initiate detailed design of a Naval UCAV demonstrator aircraft.

• Hybrid Cycle and Rocket Engines. ($ 4.000 Million)
  - Perform conceptual design, trade-studies and mission utility analysis.
  - Conduct initial technology and reusable technology demonstrations.

• Satellite Protection and Warning (SPAWN). ($ 4.000 Million)
  - Identify potential satellite threats and threat employment scenarios.
  - Define requirements for a nano-micro (10-100 kg) satellite for protection of on-orbit assets and threat characterization.
  - Identify candidate sensor technologies and characterization techniques, select approaches for further development.
  - Devise architectures and CONOPS; determine the feasibility and utility of these missions.

• Space Battle Management Command, Control and Communications (SBMC3). (4.000 Million)
  - Define computing and communication interfaces with legacy systems.
  - Devise computing and communication architectures and CONOPS; determine effectiveness in high tempo scenario with modeling and simulation.
  - Identify candidate algorithms and technologies to mitigate high-risk areas, select approaches for further development.
  - Initiate the design, development, and integration of proof-of-principle computing communications algorithms and technologies.

• Space Object Identification System (SOIS). ($ 4.000 Million)
  - Perform analysis of on-orbit imaging requirements.

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- Identify candidate ground- and space-based sensor technologies.
- Identify candidate satellite characterization algorithms.
- Analyze predicted performance of candidate technologies and select approaches for further development.

- Space Technologies. ($ 3.000 Million)
  - Initiate feasibility studies; develop conceptual designs and figures of merit for morphing/shape control of space vehicles.
  - Develop multifunctional structure concepts for reducing weight, improving survivability and adaptively changing capability of space structures.
  - Initiate design for integrated hybrid power module and quantify performance improvements in powering RF, microwave and optical system.

(U) **Program Change Summary:** (*In Millions*)

	FY 2000	FY 2001	FY 2002
Previous President's Budget	17.071	26.821	32.700
Current Budget	19.187	37.474	153.700

(U) **Change Summary Explanation:**

FY 2000 Increase reflects minor program repricing.

FY 2001 Increase reflects net effect of congressional program reductions, congressional add for Supersonic Noise Mitigation, the Section 8086 reduction and the government-wide rescission.

FY 2002 Increase reflects a major expansion of the DARPA/Air Force UCAV program that continues program acceleration initiated by the Congress in FY 2001, rephasing of the Orbital Express Space Operations Architecture effort, expansion of A160 air vehicle technology development, the addition of the Hybrid Rocket program, and transition of Naval UCAV program from a study effort to a full program.

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(U) **Other Program Funding Summary Cost:** *(In Millions)*

	FY 2000	FY 2001	FY 2002
• Unmanned Combat Air Vehicle (UCAV):			
Air Force	*	24.800	21.100
• Naval Unmanned Combat Air Vehicle (UCAV-N):			
Navy	1.500	1.500	15.000

*Classified

(U) **Schedule Profile:**

Plan	Milestones
Miniature Air-Launched Interceptor (MALI):	
Jul 01	Complete avionics environment verification testing.
Aug 01	Deliver first supersonic engine.
Aug 01	Conduct flight readiness review.
Sep 01	Captive carry flight test.
Oct 01	Perform intercept flight demonstration.
Dec 01	Complete supersonic flight demonstrations.
Advanced Air Vehicle (AAV):	
Aug 01	Design review for low-vibration rotor modifications and unmanned ground vehicle deployment system for A160.
Mar 02	A160 Electro-Optic/Infrared (EO/IR) payload first flight.
Jun 02	A160 Unmanned ground vehicle deployment system first flight.
Sep 02	A160 low vibration rotor first flight.
Jun 03	A160 Compound Helo Design Review.
Sep 03	A160 Flight with Forward Pass Ground Control Station.

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Orbital Express Space Operations Architecture:

Jun 01	Complete operational system concept, supporting trade studies, and satellite servicing CONOPS.
Sep 01	Conduct demonstration system preliminary design review. Complete demonstration system detailed test plan.
Jan 02	Select Phase II contractor team.
Mar 02	Conduct Delta preliminary design review.
Jun 02	Conduct Critical Design Review.
Aug 02	Begin subsystem fabrication; complete system level simulator for integrated software testing.
Nov 02	Begin subsystem level environmental qualification testing; Initiate fabrication of ASTRO and NextSat satellites.
Jan 03	Complete alpha version of flight software; begin testing on satellite software simulator.
May 03	Complete beta version of autonomous Guidance, Navigation and Control (GN&C) software; begin testing in full motion simulation facility.
Sep 03	Begin payload integration testing into ASTRO and NextSat buses.

Unmanned Combat Air Vehicle (UCAV):

Aug 01	System B Interim Design Review.
Jan 02	System B mid-term Design Review.
Aug 02	System B Final Design Review.

Naval Unmanned Combat Air Vehicle (UCAV-N):

Nov 01	Pegasus first flight complete.
Apr 02	Conduct 12% low speed wind tunnel test.
Sep 02	Conduct 12% high-speed wind tunnel test.
Sep 02	Distributed Control, AWACS/JSTARS, lab demonstration complete.
Nov 02	Demo & Evaluation of HIS Devices in lab and maritime environment.
Dec 02	RCS Signature demonstration complete.
Jul 03	Complete deck operations demonstration.
Jul 03	Complete MCS Navy C4I infrastructure integration demonstration.
Oct 03	Contractor X and Y UDS construction complete.
Dec 03	Conduct Next Generation SAR technology flight demonstration.

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Dec 03 Contractor Y final UDS ground tests complete.

Hybrid Cycle and Rocket Engine:
Aug 02 Complete conceptual design, trade-studies.
Sep 03 Complete initial reusable technology demonstrations.

Quiet Supersonic Platform (QSP):
Jun 01 Complete preliminary propulsion systems studies.
Sep 01 Report results of QSP technology assessment and system integration studies.
Jan 02 Complete airframe and detailed propulsion systems studies.

Space Battle Management Command, Control and Communications ($SBMC^3$):
Jul 02 Complete interface definition documentation.
Nov 02 Select teams for spacecraft hardware and ground segment automation.

Space Object Identification System (SOIS):
May 02 Complete initial requirements review.
Sep 02 Select candidate technology to pursue.

Satellite Protection and Warning (SPAWN):
Jan 02 Select team for micro/nanosatellite development and fabrication.
May 02 Complete threat characterization and initial requirements review; identify candidate sensor systems.
Oct 02 Conduct system level Preliminary Design Review; begin ordering long lead times.